The Disease Triangle as a Reusable Learning Object

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Introduction

The Internet has greatly changed the way in which we teach and do research (1, 10, 14). Schumann (12) extensively reviewed the innovations now taking place in the discipline of plant pathology, and found that many faculty now teach online courses or at least use some online components to their courses. In a few cases, faculty have developed focused "learning objects" to teach a particular concept or to provide supplemental instruction for students.

A learning object, as defined by Wiley (14), is any digital instructional content that can be re-purposed, i.e. used in a variety of settings. Similarly, Polsani (11) defines a learning object as "an independent and self-standing unit of learning content that is predisposed to reuse in multiple instructional contexts." Polsani further emphasizes that we as teachers should strive to "move beyond the text-centric approach and concentrate on designing participatory environments that engender memorable experiences in readers and audiences." We believe that knowledge from

different disciplines can be organized into a reusable learning object and easily combined to produce interesting, engaging, and interactive plant pathology educational materials.

What is a Learning Object?

In the literature, the term "learning object" has a multitude of definitions and meanings, and has generated much debate concerning these definitions (13,14). As teaching faculty realize the new instructional capabilities and possibilities to be attained via digital learning objects, the learning object term needed a standardized definition necessary for its success. Some definitions appear too broad, allowing any digital asset, such as a diagram, photograph, chart, video clip or simulation, to be classified as a learning object, while other proposed definitions are far too restrictive. Restrictive definitions seem to limit the very reusability that so commonly unites the use of learning objects (11).

In this article, we adopted a definition which generally describes our learning object module as a matrix consisting of three independent levels of competencies or proficiencies, and three progressive components of (a) content material followed by (b) an interactive student learning activity, and (c) an evaluative assessment to measure student comprehension (Figure 1)

	CONTENT	ACTIVITY	ASSESSMENT
Level 1 (Beginner)	**Introduction, Terminology, Basic Concepts**	**Game, Define, Construct, Describe, List,**	**Quiz, Test, Written Essay, Feedback**
Level 2 (Intermediate)	**Expanded Content, Exceptions, Examples**	**Apply, Associate, Restructure, Draw**	**Quiz, Test, Written essay Feedback**
Level 3 (Advanced)	**Case Studies, Expanded Content Advanced terms**	**Judge, Processing Evaluate, Decide, Synthesize**	**Quiz, Test, Written essay Feedback**

Figure 1. A learning object matrix for teaching the disease triangle and related concepts.

The content section contains the bulk of information, including images, text, and some interactive information. The activity component follows the content section providing students an opportunity to apply or use the new content material learned from the preceding content section. Lastly, an assessment section follows consisting of a set of questions or quizzes that measures and display the students' progress back to the teacher. Additionally, the module has three levels of proficiency that can be rated as level 1, or beginner; level 2, or intermediate; and level 3, or advanced. Each of these levels builds upon the other and each level can be assigned to students to complete independently or collectively.

In utilizing learning objects, students learn actively and constructively through multiple tiers of information, interactivity, and pace. If students are struggling with a particular section within a learning module, they may spend extra time and effort until fully confident in their understanding of the subject matter. Often, in classroom settings, students find themselves hesitant to seek the extra help they may need. Learning objects allow students to work at their own pace, and they may seek extra help when necessary through the resources supplied within the learning objects. Students will benefit through better knowledge retention and an improved understanding of the critical concept because of the interaction. Students may also have a greater interest in the subject matter.

Learning Objects Connected to Librarian Partnerships

Iannuzzi (5) noted that the "information literacy agenda extends beyond the library into the classroom and requires the collaboration of librarians and instructors." Faculty and librarian partnerships in teaching information skills help instructors attain their educational goals and also produce good results for students. Farber (2) provides a historical perspective on collaboration; he notes that when the cooperative relationship flourishes, both the teacher's and the librarian's learning objectives are "not only achieved but are mutually reinforcing…" The students gain a better understanding of the course subject matter and also learn to find and evaluate information. Research has shown that information literacy skills are best learned when incorporated into the curriculum, at the point of need, rather than presented in isolation (6).

Learning objects that present research skills instruction which can be included in a course or used in conjunction with another learning object, allow a unique and new collaboration between librarians and faculty. For example, The Ohio State University Libraries have developed the net.TUTOR program, a collection of research skills tutorials that fit the model of learning objects. These tutorials are reused in many different courses by faculty who wish to help students improve their research skills. Since 1997, when the program began, more than 10,000 students in 170 Ohio State University courses have used these tutorials (8). The module we describe here also illustrates this approach.

Benefits to Instructors

Instructors also benefit immensely from the use of learning objects. It allows them to be more interactive in the teaching the course, and lets them tailor the course to meet each class' diverse needs. Instructors can gain further understanding of their students' needs through feedback within the modules. In addition, they can interact with their colleagues to continuously add to the materials available in each learning object. This sort of collaboration benefits the instructors, the students, and the future students and instructors who will continue to increase the bank of information available in a learning object.

Regardless of definition, the use of learning objects opens new doors in interactive education and learning. Some of the key properties of learning objects include their reusability, accessibility, interoperability, online learning potential, hierarchical structure, and pedagogical nature (15).

The Plant Disease Triangle as a Reusable Learning Object

We believe The Plant Disease Triangle concept can be developed into an excellent example of a reusable learning object resource for plant pathology. One of the most important fundamental concepts in teaching and studying plant diseases is the "disease triangle" and its ramifications. The disease triangle is a widely used, practical conceptual model for teaching basic plant pathology. The concept is often used as a springboard to introduce students to advanced concepts on how diseases develop and the significance of plant diseases in the environment. Francl (3) provided an excellent historic account of the disease triangle paradigm in plant pathology.

This learning object module brings together not only an understanding of the disease triangle concept, but it also examines closely associated elements related to the process of disease development and epidemics. The object is available at: http://www.ag.ohio-state.edu/~triangle/. Those viewing this module will be presented with concepts, an activity, and an assessment for each of its three levels. Instructors, K-12 science education teachers, and extension educators are encouraged to use this module to further emphasize points covered in their biology curriculum, K-12 science education classes, study activities, or extension education programs. The main benefits to teachers in using this learning object module are to:

- Improve the quality of the student learning experience
- Benefit from content reusability
- Use course materials and teacher time more efficiently

Navigating the Disease Triangle Module

Suggestions for instructors on using of the learning object in teaching and extension programs are offered below:

1. **Goals**: A learning object can meet learning objectives in different ways. An awareness of the technology frees the teacher from spending class time on the triangle. Similarly, an extension educator may use the learning object to reinforce or introduce the concept in a Master Gardener program. The learning object can provide focus and reinforcement to important points the instructor wants to make during a course of instruction or workshop.

2. **Content**: Attention is called to three levels of content. Level 1 is basic, level 2 is intermediate, building on level 1, and level 3 builds on levels 1 and 2 by introducing examples of plant diseases in epidemiology. Following each content level is a student activity and then an assessment. The instructor may choose to have students follow levels 1, 2 or 3, depending on the desired level of proficiency.

3. **Concept Mapping**: Within level 3, the most advanced level, students are introduced to concept mapping. Concept maps are graphic organizers representing students' conceptual

frameworks where words represent concepts, and links represent conceptual relations (7). In this learning object, a concept map is used to provide a structure within which students may discover new relationships between plant pathology concepts. Students are presented with a scaffolded, incomplete concept map and are instructed to arrange the concepts so that the flow of the map is logical. Students are directed to examine the concept map and then drag and drop loose concepts to the correct position in the concept map. For example, when students correctly drag the "Abiotic" concept into the correct position on the concept map, a blue ring will pulsate indicating that the student has properly placed the concept. There is no response from concepts until they are properly placed onto the map.

Our use of concept mapping in our learning object is a low threshold application to help extend the ideas of plant pathology vis-a-vis the disease triangle. Additional research on more advanced examples of the use of concept mapping can be located at the Institute for Human and Machine Cognition (http://cmap.ihmc.us) or in Green's (4) dissertation at: http://www.oln.org/cgreen/dissertation/Cable_Green_Dissertation-R.pdf.

4. **Research Skills**: Users are encouraged to apply research skills by locating current research on plant diseases listed as epidemic in the "Current Events" section of the module. A net.TUTOR tutorial on "Finding Articles" provides instruction on searching various periodicals, including scholarly journals, finding aids to locate specific articles, tips for finding full-text, and strategies for assessing the value of articles. The tutorial follows the traditional "presentation, practice, feedback" model described by Orrill (9). That is, the learning object presents the information, provides the student with opportunities to practice, and contains a test allowing the computer to provide feedback to the user.

By linking research skills instruction to use of the Plant Disease Triangle module, the instructor offers students an opportunity to improve student information-seeking skills beyond the simple use of web search engines. By asking students to locate articles on topics covered in the module, instructors allow them to apply new research skills and extend their knowledge about the concepts covered in the instructional module.

Additional examples of learning objects on Life Science Processes, Information Literacy, Scientific Reasoning and Humanities, may be found on the Ohio State University "Learning Objects Portal Page" located at http://telr-research.osu.edu/menagerie.htm.

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